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WELLSCREEN HAVING HELICAL SUPPORT SURFACE

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CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a divisional of co-pending U.S. patent application Serial No. 10/007,862 filed November 9, 2001 and is herein incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to well completion methods. More specifically, the present invention relates to an apparatus and method for assembling a wellscreen for use in oil, gas, and water wells.

Description of the Related Art

[0001] Wellbores are typically formed by drilling a borehole into the earth in order to penetrate one or more hydrocarbon-bearing formations. Typically, the wellbore is supported by one or more strings of steel casing which extend from the surface to a desired depth. An annular area is created between the casing and the borehole, which is filled with cement to further support and form the wellbore.

[0002] Some wells are produced by perforating the casing of the wellbore at selected depths where hydrocarbons are found. Hydrocarbons migrate from the formation, through the perforations, and into the cased wellbore. In some instances, a lower portion of a wellbore is left open, that is, it is not lined with casing. This is known as an open hole completion. In that instance, hydrocarbons in an adjacent formation migrate directly into the wellbore where they are subsequently raised to the surface, either by production pressure or through an artificial lift system.

[0003] One problem typically encountered in connection with production of downhole fluids is the invasion of aggregate material, including sand, into the wellbore. Sand production can result in premature failure of artificial lift and other downhole and surface equipment. Sand can also build up in the tubing to obstruct

well flow. In addition, produced sand becomes difficult to handle and dispose at the surface.

[0004] The need to remove aggregates from production fluids exists in many types of wells, including oil and gas wells, water wells, geothermal wells, and wells for ground remediation. Typical particulates needing to be filtered out are sand and clay including unconsolidated particulate matter, also known as "formation sand".

[0005] To control particle flow from unconsolidated formations, well screens are often employed downhole. These well screens serve as subterranean particle filters, and are conventionally referred to as "sand screens." Sand screens have been utilized in the petroleum industry for some time to remove particulates from production fluids.

[0006] Sand screens are typically tubular in shape and serve as a filtering barrier between a formation and a string of tubing or production equipment. Modern sand screens are typically constructed from three composite layers. These include a perforated base pipe, at least one porous filter media wrapped around and secured to the base pipe, and an outer cover. The filter media allows hydrocarbons to invade the wellbore, but filters sand and other unwanted particles from entering.

[0007] The sand screen is connected to the lower end of either the casing or the production tubing. Hydrocarbons travel to the surface of the well through the sand screen and via the tubing. Thus, hydrocarbons or other production fluid are filtered before entering the production string and before traveling through expensive production and pumping equipment.

[0008] A typical method of constructing a wellscreen involves wrapping and seam-welding mesh layers of filtering material around the perforated base pipe. The mesh layers typically consist of sintered mesh filter elements and more coarse wire mesh drainage elements. An alternative method involves forming a tube of the mesh material, seam welding it longitudinally, and then sliding it over the perforated

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base pipe. A protective outer shroud consisting of a perforated tube is then placed over the mesh layers and the perforated base pipe.

[0009] **Figure 1** shows a previous version of a perforated base pipe **12** for a prior art well screen **10**. The base pipe **12** defines a tubular body having a plurality of perforations **14** therein. The base pipe **12** includes a central bore extending from a first end **20A** to a second end **20B**. At each opposite end **20A**, **20B** of the base pipe **12** is a termination member **16**. Each termination member **16** defines a series of concentric step-tiered rings **22** having progressively larger diameters. As shown in **Figure 2**, the step-tiered rings **22** of the prior art serve as support members for layers of filter screen **24** and the protective shroud (not shown) which will encompass the base pipe **12** upon completion of the well screen **10**.

[0010] A disadvantage to known well screens **10** is the cumbersome manufacturing process. To assemble the wellscreen **10**, the step-tiered rings **22** of the prior art perforated base pipe **12** (**FIG. 1**) require that the layers of filter screen **24** (shown in **FIG. 2**) be individually sized to fit each sequential tier on the termination members **22**. This means that each layer of filter screen **24** must be cut in separate pieces in accordance with the specific diameter of each corresponding step ring **22**. After being cut, the layers of filter screen **24** must be separately welded to each corresponding step ring **22**, starting with the smallest diameter ring **22'** located at the base of the termination member **16**, and moving up sequentially to each successively larger diameter ring **22** until the step ring having the largest diameter **22"** has been fitted for a layer of filter screen **24**. This process results in many individual sections of mesh material **24** being separately cut and welded to the corresponding step-tiered rings **22** of the termination members **16**.

[0011] **Figure 2** depicts an intermediate layer of filter media **22** being applied to a step ring **22** of a prior art base pipe **12**. The step is repeated for each step ring **22**. Thus, in the manufacturing process of the prior art, a plurality of layering and welding steps are required. These numerous steps represent a labor-intensive process that is both expensive and time consuming. In addition, this process also

requires a greater degree of skill from the technicians in manufacturing and maintenance.

[0012] Therefore, a need exists for a perforated tubular that enables quicker and easier fabrication welding of filter screen layers to the step rings. There is a further need for a well screen that enables the filter layers to be prepared offline for easier assembly at the shop or well site. In addition, there is a need for a method for assembly of the filter screen layers onto a helical step-tiered surface in one continuous feed welding operation.

[0013] Further yet, there is a need for a method of manufacturing a sand screen which is less expensive, and which requires less time to manufacture, assemble, and maintain than known sand screens.

SUMMARY OF THE INVENTION

[0014] The present invention first relates to an improved filtering device for filtering particulates from fluid. In the preferred embodiment, the apparatus serves as a wellscreen for filtering sand and other aggregates during production of hydrocarbons from a downhole formation.

[0015] The wellscreen first comprises a perforated base pipe. At each opposite end of the base pipe is disposed a frustoconical termination member. The termination member includes a helical step-tiered surface, which serve as a support for an intermediate filtering media for the wellscreen. Thus, unlike the individual step-type rings of the prior art, the present invention offers an outer spiraling surface. In accordance with the present invention, the spiraled step surface forms a continuous helical pattern, allowing the filtering media to be spooled and attached onto the termination members during manufacturing. Thereafter, an outer protective perforated shroud may optionally be added.

[0016] The present invention also relates to a method for assembling a wellscreen. A pre-slotted base pipe is utilized as the base member for the

wellscreen fabrication. As described above, a frusto-conical termination member is disposed at each opposite end of the base pipe. The termination member includes a spiraled step surface, which serves as a support surface for an intermediate filtering layer for the wellscreen. In accordance with the present invention, the spiraled step surface forms a continuous helical pattern, allowing a filtering media to be dispensed and attached onto the termination members in a single roll.

[0017] The base pipe, including the opposite termination members, is positioned onto a spool. The filtering layer is then cut and fed through a tensioning roller and attached onto the smallest diameter of the termination members. Thereafter, the spool is rotated so as to roll the filtering media onto the tiers of the termination members.

[0018] An outer protective perforated shroud may optionally be added to the base pipe and filtering media. The filtering media and the outer shroud are preferably welded onto the termination members to form a secure containment for the base pipe.

[0019] The completed wellscreen is designed to serve as an inlet port for production fluids in a downhole wellbore. Accordingly, the wellscreen is positioned in series with a string of production tubing or, in an open-hole completion, a string of casing, downhole. The wellscreen thus defines a multi-layered tubular, allowing fluids to be filtered and to enter production tubing. In one embodiment, the wellscreen includes a threaded pipe section at least one end to facilitate the fluid connection of the wellscreen to the production tubing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] So that the manner in which the above recited features, advantages and objects of the present invention are attained and can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to the embodiments thereof which are illustrated in the appended drawings.

[0021] It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0022] Figure 1 is an exploded view of a prior art version of a perforated base pipe for a wellscreen. Step-tiered pyramid rings are disposed on opposite termination members.

[0023] Figure 2 is also a prior art version of a portion of a wellscreen. Visible is a layer of filtering media being placed onto a single step-tiered ring.

[0024] Figure 3 is a plan view of an end of a base pipe of the present invention. At the depicted end of the base pipe is a termination member having a helical step surface.

[0025] Figure 4 is a cross sectional view of a wellscreen taken along line 4-4 of FIG. 3.

[0026] Figure 5 is a perspective view of a wellscreen of the present invention being assembled. A base pipe for the wellscreen is shown, having opposite termination members. A filtering media is also shown, ready to be spooled onto the spiraled surfaces residing on the termination members.

[0027] Figure 6 is a plan view of the wellscreen of FIG. 5, with the filtering media being spooled onto the spiraled surfaces of each end. FIG. 6 demonstrates that the filtering media is pre-cut to the correct diameter for rolling onto the perforated base pipe. In this view, the initial portion of the filtering media has covered the perforations of the base pipe.

[0028] Figure 7 is a plan view of the base pipe of the present invention having a continuous helical surface on each end. In this view, the wellscreen has been completely rolled onto the base pipe.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0029] **Figure 3** is a plan view of an end **70A** of a wellscreen **50** of the present invention. The wellscreen **50** first includes a base pipe **52** having a plurality of slots, or perforations, **54** formed therein. The diameter and the number of perforations **54** may vary depending on the particular operation.

[0030] At the depicted end **70A** of the base pipe **52** is a termination member **66**. The termination member **66** is connected to and resides at the end **70A** of the base pipe **52**. The termination member **66** is generally frustoconical in shape, and has disposed thereon a continuous helical step surface **72**. As will be shown in **Figure 5**, the helical step surface **72** serves as a support member for an intermediate filtering media **74**.

[0031] In accordance with the present invention, the spiraled step surface **72** defines a continuous helical pattern. To accomplish this, each of the two helical support surfaces, steps, **72** first has a lead point **71A, 71B** on a first step-tier **72'**. The lead point **71A**, **71B** is the point at which the leading edge **76** of the filtering material **74** is overlaid onto each termination member **66**. Further, each of the two helical support surfaces **72** has an end point **73A**, **73B** on a last step-tier **72"**. This is the point at which the trailing edge **80** of the filtering material **74** is overlaid onto the termination member **66**. Thus, each support surface **72** defines a series of outer spiraling support steps having a lead point **71A**, **71B** and an end point **73A**, **73B**, such that the diameter of each termination member **66** grows larger as the helical support surface **72** progresses from the lead point **71A**, **71B** to the end point **73A**, **73B**.

[0032] **Figure 5** demonstrates that the first step-tier **72'** on the termination member **66** is positioned closest to the perforations **54** of the base pipe **52**, and has the smallest diameter. In this respect, the lead point **71A**, **71B** is proximal to the perforations **54**. The last step-tier **72"** is positioned farthest from the perforations **54** of the base pipe **52** and has the largest diameter. There is at least one step-tier 72 intermediate the first **72'** and last **72"** step tiers forming a helical pattern. The helical

pattern allows the filtering media **74** to be spooled onto the termination members **66**, either as a single sheet of material or as a series of spooled sections. Thus, the wellscreen **50** of the present invention differs from wellscreens of the prior art **10**, in that the wellscreen **50** of the present invention does not utilize separate concentric step-tiered rings **22** for supporting a large number of separate filtering media **24** layers.

[0033] The perforated base pipe **52** defines a tubular body having an inner bore **58** for transmitting fluids within the wellbore (not shown) to the surface. In the depiction of **Figure 3**, bore **58** in end **70A** defines a port for fluid flow. A threaded connector **60A** is provided to allow a threaded connection with production string (not shown). In the embodiment of **FIG. 3**, threaded connector **60A** defines a male coupling. However, it is within the scope of this invention to provide a wellscreen **50** which is placed in series with the casing (not shown).

[0034] **Figure 4** is a cross sectional view of a well screen **50** taken along line **4-4** of **FIG. 3**. The bore **58** of the base pipe **52** is seen centrally. Also visible is the continuous helical step surface **72**, starting with the smallest step-tier **72'**, and terminating at the end with the largest step-tier **72''**. In the design for the present invention, the helical step surface actually defines a continuous spiral.

[0035] **Figure 5** is a plan view of a wellscreen **50** of the present invention being assembled. The base pipe **52** for the wellscreen **50** is shown, having a central bore **58** and a plurality of perforations **54**. The base pipe **52** also includes opposite termination members **66**. The entire length of filtering media **74** is also shown, ready to be spooled onto the spiraled rings **72** residing on the termination members **66**.

[0036] Both termination members **66** are visible in **FIG. 5**. The termination members are disposed on opposite ends **70A** and **70B** of the wellscreen **50**. In the preferred embodiment, each end **70A**, **70B** also defines a communication member for providing a fluid seal with the production tubing (not shown). For example, one

end **70A** could define the male portion of a threaded coupling **60A** (threads shown in **FIG. 3**), and one end **70B** could define the female portion of a threaded coupling (threads not shown).

[0037] Each termination member **66** has a first step step-tier **72'** having a smallest diameter. The distance between the two first step step-tier **72'** is identified as **D'**. Each termination member **66** also has a last step-tier **72"** having a largest diameter. The distance between the two second step-tiers **72'** is identified as **D"**. Intermediate each first **72'** and last **72"** step-tiers is at least one intermediate step-tier **72**. Each successive step-tier (**72'** to **72"**) thus increases in diameter as the outer surface of the termination member **66** spirals.

[0038] **Figure 6** is a plan view of a wellscreen **50** of the present invention being assembled. In this view, the perforations of the base pipe **52** for the wellscreen **50** have been covered by the initial section **77** of filtering media **74**. Likewise, the smallest step-tier **72'** has been covered. However, additional levels of the step-tiers **72** remain to be covered during assembly, including the largest step-tier **72"**.

[0039] As can be seen in **FIG. 5** and **FIG. 6**, the filtering layer **74** has been pre-cut to match the diameters and bias of the step surface **72**. Thus, the filtering layer at its leading edge **76** has a width of **D'**,. The filtering media then tapers outwardly so that at its trailing edge **80** the filtering media has a width of **D"**. In this arrangement, side edges **82A** and **82B** define a pair of opposite hypotenuse sides which match the helix angle of the helical support surface. The bias angles of edges **82A** and **82B** match the lead angles of the spiral surfaces **72** on termination members **66**.

[0040] The filtering media **24** for wellscreens **10** of the prior art consists of various layers of drainage mesh and filter mesh layered together in an alternating fashion. The filtering layers essentially define sections of sintered and non-sintered mesh. It is noted that the sintering process involves increasing the temperature of the various components to approximately eighty percent of the melting temperature

and fusing the components together. The respective ends of the filtering media layers are wrapped onto corresponding step-tiered rings **22**, and welded or otherwise connected to the termination members **16**. The alternating layers of the various meshes ensure filtering without restricting the flow of fluids into and along the surface of the wellscreen.

[0041] In the wellscreen **50** of the present invention, alternating layers **74** of sintered and non-sintered mesh are still employed. The lead section **77** of filtering media **74** is preferably a non-sintered piece, and is the piece used to attach to the first step-tier **72'**. Attachment is preferably by welding. The base pipe **52** is spooled so as to draw the filtering media **74** around the perforations **54**. As the filtering media **74** is spooled, the intermediate helical surface **72** is invoked for support. The intermediate section **78** of filtering media is, in the preferred embodiment, a sintered mesh material. During the spooling process, the side edges **82A**, **82B** of the filtering media are preferably welded to the helical surface **72**. The filtering media material **74** is sized so that the trailing edge **80** will cover the last step-tier **72''**. Preferably, the last section **79** of filtering media **74** is a non-sintered mesh.

[0042] **Figure 7** is a plan view of the wellscreen **50** of the present invention after the filtering material **74** has been completely rolled onto the perforated base pipe **52**. Trailing edge **80** of the filtering materials **74** is visible. Thereafter, an outer protective perforated shroud (not shown) may optionally be added.

[0043] The present invention also discloses a method for creating a wellscreen. According to the present method, a perforated base pipe **52** is utilized as the base member for the wellscreen **50** fabrication. As described above, a frustoconical termination member **66** is disposed at each opposite end of the base pipe **52**. Each termination member **66** includes a continuous helical step surface **72**, which serves as a support for a filtering layer **74** for the wellscreen **50**. In accordance with the present invention, the helical step surface **72** forms a continuous spiral pattern, allowing a filtering media **74** to be dispensed onto the termination members **66** in a single roll.

[0044] While it is contemplated that the sintered **78** and non-sintered **77, 79** portions of the filtering material **74** would be fabricated into a single continuous roll, it is within the scope of this invention to provide separately cut sections of sintered and non-sintered material which would be rolled in proper order. In this embodiment, the filtering material **74** would be a plurality of continuous layers, preferably comprising alternating sintered **78** and non-sintered **77, 79** sections.

[0045] The base pipe **52**, including the opposite termination members **66**, is positioned onto a spool (not shown). The pre-cut filtering layer **74** is then fed through a tensioning roller onto the smallest step-tier **72'** of the termination members **66** from a tensioning roller (also not shown). Thereafter, the spool is rotated so as to roll the filtering media **74** onto the rings **72** of the termination members **66**.

[0046] An outer protective perforated shroud may optionally be added to the base pipe **52** and filtering media **74**. The filtering media **74** and the outer shroud are preferably welded onto the termination members **66** to form a secure containment for the perforated base pipe **52**.

[0047] At this point, the perforated base pipe **52** with spiraling surface **72** is now assembled into wellscreen **50** of the present invention, and can be placed into the appropriate position in the production tubing string (not shown). The completed wellscreen is designed to serve as an inlet port for production fluids in a downhole wellbore. Accordingly, the wellscreen **50** is preferably positioned in series with a string of production tubing downhole. The wellscreen **50** thus defines a multi-layered tubular, allowing fluids to be filtered as they enter the production tubing. In one embodiment, the wellscreen includes a threaded pipe section at least one end to facilitate the fluid connection of the wellscreen to the production tubing.

[0048] While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.